PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference GRM : FP 5793	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International application No. **PCT/AU 98/00115**	International filing date *(day/month/year)* 24 February 1999	Priority Date *(day/month/year)* 24 February 1997
International Patent Classification (IPC) or national classification and IPC **Int. Cl.**[6] C22C 21/02, 21/04		
Applicant (1) CAST CENTRE PTY LTD (2) BARRESI, Joseph Giovanni (et al)		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of **4** sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheet(s).

3. This report contains indications relating to the following items:

I	☒	Basis of the report
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☐	Lack of unity of invention
V	☒	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain documents cited
VII	☐	Certain defects in the international application
VIII	☒	Certain observations on the international application

Date of submission of the demand 18 September 1998	Date of completion of the report 12 January 1999
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. (02) 6285 3929	Authorized Officer L.J. MENZ Telephone No. (02) 6283 2347

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/AU 98/00115

I. Basis of the report

1. With regard to the elements of the international application:*

- [X] the international application as originally filed.
- [ ] the description, pages , as originally filed,
  pages , filed with the demand,
  pages , filed with the letter of .
- [ ] the claims, pages , as originally filed,
  pages , as amended (together with any statement) under Article 19,
  pages , filed with the demand,
  pages , filed with the letter of .
- [ ] the drawings, pages , as originally filed,
  pages , filed with the demand,
  pages , filed with the letter of .
- [ ] the sequence listing part of the description:
  pages , as originally filed
  pages , filed with the demand
  pages , filed with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

- [ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- [ ] the language of publication of the international application (under Rule 48.3(b)).
- [ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, was on the basis of the sequence listing:

- [ ] contained in the international application in written form.
- [ ] filed together with the international application in computer readable form.
- [ ] furnished subsequently to this Authority in written form.
- [ ] furnished subsequently to this Authority in computer readable form.
- [ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- [ ] The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. [ ] The amendments have resulted in the cancellation of:
   - [ ] the description, pages
   - [ ] the claims, Nos.
   - [ ] the drawings, sheets/fig

5. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/AU 98/00115

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-14	YES
	Claims		NO
Inventive step (IS)	Claims	1-14	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-14	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

Citations

(a) AU 41041/78
(b) AU 35111/78
(c) AU 86630/75

Explanations

The citations do not disclose or suggest A1-Si-Mg alloys with a microstructure including a primary aluminium containing matrix and one or more iron-containing phases dispersed in the matrix and wherein the sole or predominant iron-containing phase is β phase that formed as a transition product of π phase.

Therefore claims 1 to 14 are novel and have inventive step.

The invention, as claimed, is industrially applicable.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/AU 98/00115

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

The broad statements of invention and the corresponding claims 1 and 5 detail an alloy composition where Fe is present in an amount up to 0.05%. Therefore the alloy includes the possibility that no Fe is present. However, when referring to the phase structure of the alloy, the invention is characterised by iron-containing phases requiring the presence of some Fe in the alloy.

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FOUNDRY ALLOY

The present invention relates to an improved foundry alloy and to a method of producing an improved foundry alloy. In particular, the improved foundry alloy is an aluminium-based alloy.

Primary metal based foundry alloys are largely used for structural or safety type applications where there is a requirement for high and consistent mechanical properties. The majority of components made from aluminium foundry alloys are made from hypoeutectic aluminium-silicon-magnesium alloys containing a nominal silicon level of 7% by weight (601 and 603 designations). In simple terms these alloys are a composite of hard, discontinuous silicon particles and large, brittle iron intermetallics embedded in a ductile aluminium matrix.

There are three registered Australian compositions for strontium-modified aluminium - 7% silicon alloys. These are given in Table 1. The magnesium content of the alloys covers the range 0.25 to 0.4 wt% (601 alloys) and 0.45 to 0.7 wt% (603 alloys). The addition of magnesium allows castings to be heat treated to form magnesium silicide precipitates. These harden the matrix of the alloy to obtain the desired combination of strength and ductility.

Table 1. Registered alloy composition for strontium modified 601/603 type foundry alloys

Alloy Code	Si	Fe	Cu	Mn	Mg	Zn	Ti	Other Each	Other Total	Al
AC601	6.5-7.5	0.20	0.05	0.05	0.30-0.40	0.05	0.20	0.05	0.15	Rem
CC601	6.5-7.5	0.20	0.05	0.05	0.25-0.35	0.05	0.20	0.05	0.15	Rem
AC603	6.5-7.5	0.15	0.05	0.03	0.45-0.7	0.05	0.20	0.05	0.15	Rem

♠ **Compositions in weight percent. Compositions indicate a maximum unless a range is given**

The main impurity found in these alloys is iron. The iron solidifies from the eutectic liquid into a number of brittle phases.

The two major iron-containing phases found in these alloys are the π phase ($Al_8Si_6Mg_3Fe$) which is the predominant phase formed in high Mg content alloys and the β phase (Al_5SiFe) which forms in low magnesium content alloys. The π phase forms into a script morphology while the β phase is less voluminous and forms into acicular plates. Both phases are detrimental to mechanical properties. High Mg contents (ie greater than 0.6 wt% Mg) are desirable to provide higher strength, but the presence of π phase at high Mg contents causes the ductility of the alloys to unfavourably decrease.

Conventional theories on the micro-mechanics of failure of premodified 601 and 603 alloys state that the iron rich intermetallic phases are critical in determining the fracture toughness as the silicon particles are small and round. Increases in the magnesium content of these alloys increase the amount of the π phase, which has a negative impact on the ductile properties of the alloys.

Further, as some magnesium is contained in the π phase, the maximum volume fraction of magnesium silicide precipitates cannot be obtained. Thus, the alloys do not achieve the maximum possible strength consistent with their magnesium content.

Also, as the magnesium content of an alloy increases the magnesium content of the π phase may change leading to even greater volume fractions of the phase for a given Fe content.

It is thus concluded that the overall quality of

an alloy, as given by the quality index, decreases as increasing volume fractions of the π phase forms at increased magnesium contents. The quality index is given by the formula:

$$Q.I. = UTS + 150 \log_{10} E$$

where:

Q.I. = Quality Index (Mpa)
UTS = Ultimate Tensile Strength (Mpa)
E = Elongation at Fracture (%)

Attempts have been made to eliminate the π phase and thus remove its detrimental impact on mechanical properties.

By way of example, beryllium additions can be used to precipitate the iron impurity as part of the $BeSiFe_2Al_8$ phase. This beryllium-containing phase forms in preference to the π phase, leading to alloys with improved mechanical properties. Unfortunately, there are serious health hazards associated with using beryllium. Consequently, beryllium modification is not widely practised and the deleterious effect of the π phase on alloy quality remains.

Other attempts to modify the iron-containing phases, for example by using Mn, have been tried in secondary alloys but have not been used in primary alloys.

It is an object of the present invention to provide an improved foundry alloy.

In accordance with the present invention this object is achieved by an alloy having a microstructure in which β phase that forms during heat treatment as a transformation product of π phase is the sole or

predominant iron-containing phase. The reduction in π phase results in an improvement in ductility. Moreover, the β phase that forms as the transformation product has a fine structure that improves ductility. Further, the reduction in π phase means that there are higher levels of Mg in solution which are available for precipitation during ageing to improve the strength of the alloy.

In a first aspect, the present invention provides an alloy which comprises:

Si	:	6.5 - 7.5 wt%
Fe	:	up to 0.20 wt%
Cu	:	up to 0.05 wt%
Mn	:	up to 0.05 wt%
Mg	:	0.35 to 0.50 wt%
Zn	:	up to 0.05 wt%
Ti	:	up to 0.20 wt%

Balance : Al and other components, the other components comprise a total of not more than 0.15 wt% and any single component of the other components does not exceed 0.05 wt%, the alloy having a microstructure which includes a primary aluminium-containing matrix and one or more iron-containing phases dispersed in the matrix, and wherein the sole or predominant iron-containing phase is β phase that formed as a transformation product of π phase.

It is preferred that the dendrite arm spacing of the matrix be 10-45μm.

Where there is more than one iron-containing phase, preferably the iron-containing phases also include π phase.

Preferably, the iron-containing phases include π phase in an amount up to 30 vol% of the iron-containing

phases. The amount of π phase may be higher if the Mg content is in the upper end of the range.

The Mg content of the alloy is preferably 0.40-0.45 wt%. Within this Mg range, the alloy is a variant of the 601/603 type foundry alloy. It has been realised by the applicant that close control of the magnesium content to be between 0.40 and 0.45 wt% can lead to an increase in alloy quality and improved mechanical properties. In particular, when the magnesium content is controlled to be between 0.40 and 0.45 wt% the variation in alloy quality for a small change in magnesium level is minimal. Thus, the consistency in the mechanical properties of the alloy is maximised.

The present invention also provides a method for manufacturing an alloy article.

In a second aspect, the present invention provides a method for manufacturing an alloy article which comprises:

(a) providing a melt having a composition of:

Si	:	6.5 - 7.5 wt%
Fe	:	up to 0.20 wt%
Cu	:	up to 0.05 wt%
Mn	:	up to 0.05 wt%
Mg	:	0.35 to 0.50 wt%
Zn	:	up to 0.05 wt%
Ti	:	up to 0.20 wt%

Balance : Al and other components, the other components comprising a total of not more than 0.15wt% and any single component of the other components not exceeding 0.05 wt%,

(b) casting said melt and solidifying a casting

at a cooling rate that produces a microstructure of an aluminium-containing matrix and π and β iron-containing phases dispersed in the matrix;

(c) solution heat treating the casting to at least partially transform π phase to β phase; and

(d) quenching the casting to form the alloy article.

It is preferred that the cooling rate be sufficient to produce a dendrite arm spacing in the matrix in the casting of 10-45μm.

Preferably, the sole or predominant iron-containing phase in the alloy article is β phase.

Where there is more than one iron-containing phase in the alloy article, preferably the iron-containing phases also include π phase. More preferably, the iron-containing phases in the alloy article include π phase in an amount of up to 30 vol% of the iron-containing phases. Higher levels of π phase may be present if the Mg content is at the upper end of the above range.

It is preferred that the step of solidifying the casting produces iron-containing phases that include a substantial proportion of the π phase and the subsequent solution heat treatment step is effective to convert at least some and preferably a majority of the π phase to β phase to give a microstructure in the alloy article that includes iron-containing phases which are predominantly β phase.

The melt prior to casting may be at a temperature

above the liquidus temperature of the alloy, with the melt having sufficient superheat to fill the mould, that is at a temperature of 680-720°C.

The solution treatment of the casting may be carried out at any suitable temperature and for any suitable time to achieve a desired level of transformation of π phase β phase. In any given situation, the selection of the parameters of temperature and time will depend on variables, such as the concentrations of magnesium and other elements in the casting. By way of example, the applicant has found that for castings having a Mg concentration of 0.5 wt%, solution treatment at 540°C for 2 or more hours produced desired levels of transformation of π to β phase

After the solution heat treatment, the casting is preferably quenched, more preferably quenched in hot water, such as hot water having a temperature of 70-80°C.

After quenching, the alloy article is cooled to room temperature and optionally subjected to an ageing heat treatment.

The ageing heat treatment may include heating the alloy article to a temperature of 140-170°C and holding at that temperature for 1-10 hours. After the ageing heat treatment, the alloy article may be air cooled to room temperature.

Results to support the present invention are given in Figure 1, in which plots of typical response surfaces derived from experimentally determined quality index data are shown. The three surfaces correspond to alloys that were cast at different solidification rates and thereafter solution treated and aged. Solidification rate is commonly measured by the as-cast dendrite cell size or

secondary dendrite arm spacing (DAS) but other methods exist. The results here use secondary dendrite arm spacing to indicate solidification rate, with a small dendrite arm spacing corresponding to a high solidification rate.

It can be seen from Figure 1 that:

(i) at the high solidification rate (≈20μm DAS) the alloy quality peaks at a magnesium level of 0.45-0.50 weight percent;

(ii) at the intermediate solidification rate (≈40μm DAS) the quality peaks at a magnesium level of 0.35-0.40 weight percent; and

(iii) at the low solidification rate (≈60μm DAS) the quality maximum occurs at a magnesium level of 0.25-0.30 weight percent.

Further, it can be seen from Figure 1 that the magnesium level for the peak quality is independent of the iron level for the iron levels examined. Also, the rate of change of the response surfaces with magnesium is least near the peak in quality index. This means that the alloys at the peak are less sensitive to changes in magnesium than other alloys. The peak quality from Figure 1 corresponds well with microstructural evidence for small amounts of π phase in the alloy. By increasing the magnesium content of the alloy, it can be seen that in some circumstances improved quality results.

It should be noted that the present invention works best with those casting designs or casting methods which produce high solidification rates (≤45μm DAS), such as permanent mould, mould chill methods with sand, and squeeze casting. Indeed, the trend in the automotive industry is to move away from thick section, low

solidification rate (high DAS) castings towards lightweight castings with thinner sections and higher solidification rates (low DAS).

The common belief prior to the present invention was that low magnesium levels produce high quality castings. The results shown here confirm this to be true at low solidification rates (Figure 1c). However, at higher solidification rates, the magnesium contents covered by this invention show, surprisingly, improved alloy quality and therefore improved mechanical properties.

Figures 2(a) to 2(c) are photomicrographs of hypoeutectic alloys having a Si concentration of 7 wt% and various Mg concentrations which were cast at the same solidification rate (60μm DAS), solution treated, and aged. Figure 2(d) is a photomicrograph of the as-cast alloy of Figure 2(c), ie before heat treatment.

In Figure 2(a), the Mg content of the alloy is higher than the Mg content of the alloy of the present invention. The main phases shown in Figure 2(a) are spheroidal silicon-containing phase and the iron-containing π phase.

Figure 2(b) shows the microstructure of an alloy containing less Mg than the alloy of the present invention. The phases present include spheroidal silicon-containing phase and iron-containing β phase. The β phase is present as structures of high aspect ratio dispersed throughout the matrix.

Figure 2(c) shows the microstructure of an alloy of the present invention. The phases include spheroidal silicon-containing phases, a small amount of π phase and β phase. The β phase is present as structures of high aspect ratio clumped together. This is consistent with the β

phase being formed by transformation of π phase during heat treatment.

Figure 2(d) shows that prior to heat treatment the as-cast alloy of Figure 2(c) had regions of π phase. As is evident from Figure 2(c) these π phase regions were largely transformed to β phase during heat treatment.

The drive for alloys with improved mechanical properties stems from the major restraint that mechanical properties place on the design of the casting, or even if a cast alloy can be used to manufacture a certain component. The thickness of critical sections needs to be sufficiently large that the cast component can operate without failure. Mechanical properties of the alloys therefore limit the minimum weight of a cast component. Further, the thickness of sections of a casting will determine the time required for the casting to solidify. For certain casting methods, such as low pressure die casting, the production rate is often determined by the solidification rate as the casting machine is tied up until the casting has fully solidified. Finally, the solution treatment, quench rate and ageing treatment of a cast component may be tailored to its design so as not to induce unnecessarily high residual stresses. High residual stresses can cause distortion of the component requiring additional machining. The mechanical properties of the base alloy therefore affect all stages of manufacturing from design, to casting the component, heat treatment, machining, final weight and production rate.

The present invention therefore has the following more specific applications:

(i) New markets for aluminium-7% silicon foundry alloys. Cast alloys generally have inferior mechanical properties but lower manufacturing costs compared to similar

components made from wrought alloys. The high mechanical property requirements of some components necessitates the use of wrought alloys. The achievement of alloys of the present invention which have higher and more consistent mechanical properties than conventional alloys may allow the use of the alloy of the present invention to replace wrought alloys, or other cast alloys, for some components.

(ii) Cast components with thinner sections and lower total weight. The improved and more consistent mechanical properties of the alloy of the present invention allows components with thinner sections to be designed and cast. Despite their thinner sections, these components can still operate without failure and will have a lower total weight.

(iii) Cast components with an improved production rate. Castings with thinner sections may require less time to solidify. Production equipment will then be tied up for less time waiting for a component to solidify. The production rate is thus increased.

(iv) Cast components with refined iron and silicon intermetallic phases. The solidification time of a casting strongly determines the coarseness of the microstructure. Components with thinner sections and therefore higher solidification rates (and lower solidification times) will have a more refined microstructure. This refining of the microstructure will provide

additional improvements to the mechanical properties of a casting, independent of the use of a superior alloy.

(v) Cast components with reduced heat treatment time. Castings with thinner sections require less time to homogenise. Further, the time required for the casting to reach the solution treatment temperature or ageing temperature will be less. This also benefits the production rate of components.

(vi) Cast components with increased quench rate. Thinner castings may quench more rapidly. This may lead to improved mechanical properties as it suppresses the formation of magnesium-silicide precipitates during cooling. These improved properties are independent of any refinement of the microstructure or the use of a superior alloy.

It will be appreciated that the invention described herein is susceptible to variation and modifications other than those specifically described. It is to be understood that the invention encompasses all such variations and modifications that fall within its spirit and scope.

CLAIMS:

1. An alloy which comprises:

Si	:	6.5 - 7.5 wt%
Fe	:	up to 0.20 wt%
Cu	:	up to 0.05 wt%
Mn	:	up to 0.05 wt%
Mg	:	0.35 to 0.50 wt%
Zn	:	up to 0.05 wt%
Ti	:	up to 0.20 wt%

Balance : Al and other components, the other components comprise a total of not more than 0.15 wt% and any single component of the other components does not exceed 0.05 wt%, the alloy having a microstructure which includes a primary aluminium-containing matrix and one or more iron-containing phases dispersed in the matrix, and wherein the sole or predominant iron-containing phase is β phase that formed as a transformation product of π phase.

2. The alloy defined in claim 1, wherein when the alloy includes more than one iron-containing phase, the iron-containing phases also include π phase.

3. The alloy defined in claim 2, wherein the π phase is up to 30 vol% of the iron-containing phases.

4. The alloy defined in any one of the preceding claims, wherein the Mg content of the alloy is 0.40-0.45 wt%.

5. A method for manufacturing an alloy article which comprises:

(a) providing a melt having a composition of:

Si	:	6.5 - 7.5 wt%
Fe	:	up to 0.20 wt%
Cu	:	up to 0.05 wt%
Mn	:	up to 0.05 wt%
Mg	:	0.35 to 0.50 wt%
Zn	:	up to 0.05 wt%
Ti	:	up to 0.20 wt%

Balance : Al and other components, the other components comprising a total of not more than 0.15wt% and any single component of the other components not exceeding 0.05 wt%,

(b) casting said melt and solidifying a casting at a cooling rate that produces a microstructure of an aluminium-containing matrix and π and β iron-containing phases dispersed in the matrix;

(c) solution heat treating the casting to at least partially transform π phase to β phase; and

(d) quenching the casting to form the alloy article.

6. The method defined in claim 5, wherein the cooling rate is sufficient to produce a dendrite arm spacing in the matrix of between 10 and 45μm.

7. The method defined in claim 5 or claim 6, wherein the sole or predominant iron-containing phase in the alloy article is β phase.

8. The method defined in claim 5, wherein when the alloy includes more than one iron-containing phase in

the alloy article, the iron-containing phases also include π phase.

9. The method defined in claim 8, wherein the π phase is up to 30 vol% of the iron-containing phases.

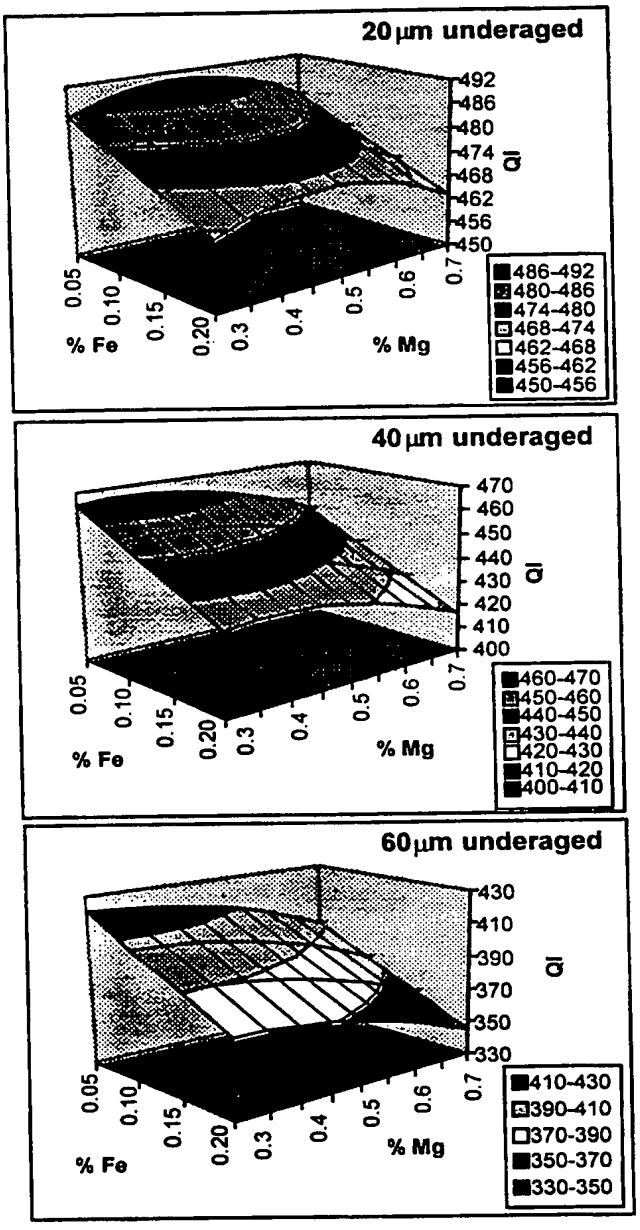
10. The method defined in claim 5 or claim 6, wherein the step of solidifying the casting produces iron-containing phases that include a substantial proportion of π phase and the subsequent solution heat treatment step is effective to convert a majority of the π phase to β phase to give a microstructure in the alloy article that includes iron-containing phases which are predominantly β phase.

11. The method defined in any one of claims 5 to 10, wherein prior to casting the melt is at a temperature above the liquidus temperature of the alloy.

12. The method defined in any one of claims 5 to 11, wherein the quenching step is in hot water having a temperature of 70-80°C.

13. The method defined in any one of claims 5 to 12, further includes an ageing heat treatment of the alloy article.

14. The method defined in claim 13, wherein the ageing heat treatment includes heating the alloy article to a temperature of 140-170°C, holding the alloy article at that temperature for 1-10 hours, and air cooling the alloy article to room temperature.


20 µm underaged
492
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486-492
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40 µm underaged
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410-420
400-410
60 µm underaged
430
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390
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330
QI
410-430
390-410
370-390
350-370
330-350

Figure 1

Figure 2 a Mag. X200

Figure 2 b Mag. X200

Figure 2 c Mag. X500

Figure 2 d Mag. X200

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 98/00115

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: C22C 21/02, 21/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C22C 21/02, C22C 21/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
STN database - alloy search (Al and 0.35<=mg<0.5 and 6.5<=Si<=7.5 and Fe<=0.2) and (Phase# or Precipitat # or Zone #)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	AU,A, 41041/78 (AU,B, 515605) (ALUMINIUM COMPANY OF AMERICA) 1 May 1980 In General	1
A	AU,A, 35111/78 (MESSIERS S A) 18 October 1979 In General	1
A	AU,A, 86630/75 (AU,B, 507432) (ALCAN RESEARCH AND DEVELOPMENT) 19 May 1977 In General	1

☐ Further documents are listed in the continuation of Box C

☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
17 April 1998

Date of mailing of the international search report
- 8 MAY 1998

Name and mailing address of the ISA/AU
AUSTRALIAN PATENT OFFICE
PO BOX 200
WODEN ACT 2606
AUSTRALIA
Facsimile No.: (02) 6285 3929

Authorized officer
L.J. MENZ
Telephone No.: (02) 6283 2431

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/AU 98/00115

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
AU	41041/78	CA	1084661	DE	2848653	FR	2415002
		GB	2007547	JP	54099762	US	4146163
AU	35111/78	CH	624716	FR	2388892		
AU	86630/75	AT	8708/75	BE	835582	BR	7507572
		CA	1041880	CH	606460	DE	2551295
		DK	5124/75	ES	442619	FR	2291284
		GB	1529305	HK	411/79	IN	149783
		IT	1049091	JP	51073913	MY	2/83
		NL	7513351	NO	753833	NO	794344
		SE	7512813	US	4126486	YU	2831/75
		ZA	7506999				

END OF ANNEX

28 Rec'd PCT/PTO 24 AUG 1999

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* GRM:FP5793

Box No. I TITLE OF INVENTION

IMPROVED FOUNDRY ALLOY

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

CAST CENTRE PTY LTD
C/- DEPARTMENT OF MINING
METALLURGICAL ENGINEERING
THE UNIVERSITY OF QUEENSLAND
ST LUCIA, QUEENSLAND 4072
AUSTRALIA

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(i.e. country)* of nationality: AUSTRALIA

State *(i.e. country)* of residence: AUSTRALIA

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

BARRESI, JOSEPH GIOVANNI
17 MARY BYRANT COURT
MILL PARK, VICTORIA 3082
AUSTRALIA

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: AUSTRALIA

State *(i.e. country)* of residence: AUSTRALIA

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

GRIFFITH HACK
509 ST KILDA ROAD
MELBOURNE, VICTORIA 3004
AUSTRALIA

Telephone No. (61 03)9243 8300

Facsimile No. (61 03)9243 8333

Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. 2

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

COUPER, MALCOLM JAMES
49 ORONSAY CRESCENT
DIAMOND CREEK, VICTORIA 3089
AUSTRALIA

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: AUSTRALIA

State *(i.e. country)* of residence: AUSTRALIA

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

ST JOHN, DAVID HENRY
26 GLADSTONE STREET
INDOOROOPILLY, QUEENSLAND 4068
AUSTRALIA

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: AUSTRALIA

State *(i.e. country)* of residence: AUSTRALIA

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

EDWARDS, GEOFFREY ALAN
18 HIGHVIEW TERRACE
DAISY HILL, QUEENSLAND 4127
AUSTRALIA

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: AUSTRALIA

State *(i.e. country)* of residence: AUSTRALIA

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

WANG, HAO
14/29 VILLA STREET
ANNERLEY, QUEENSLAND 4103
AUSTRALIA

This person is:
- [ ] applicant only
- [x] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: CHINA

State *(i.e. country)* of residence: AUSTRALIA

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [x] the United States of America only
- [ ] the States indicated in the Supplemental Box

- [ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- ☐ AP ARIPO Patent: GH Ghana, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☐ EA Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☐ EP European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☐ OA OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- ☐ AL Albania .....
- ☐ AM Armenia .....
- ☐ AT Austria .....
- ☒ AU Australia .....
- ☐ AZ Azerbaijan
- ☐ BA Bosnia and Herzegovina .....
- ☐ BB Barbados
- ☐ BG Bulgaria .....
- ☐ BR Brazil .....
- ☐ BY Belarus
- ☐ CA Canada
- ☐ CH and LI Switzerland and Liechtenstein
- ☐ CN China .....
- ☐ CU Cuba .....
- ☐ CZ Czech Republic .....
- ☐ DE Germany .....
- ☐ DK Denmark .....
- ☐ EE Estonia .....
- ☐ ES Spain .....
- ☐ FI Finland .....
- ☐ GB United Kingdom
- ☐ GE Georgia .....
- ☐ GH Ghana .....
- ☐ HU Hungary .....
- ☐ IL Israel .....
- ☐ IS Iceland
- ☒ JP Japan .....
- ☐ KE Kenya .....
- ☐ KG Kyrgyzstan .....
- ☐ KP Democratic People's Republic of Korea .....
- ☒ KR Republic of Korea .....
- ☐ KZ Kazakstan .....
- ☐ LC Saint Lucia
- ☐ LK Sri Lanka
- ☐ LR Liberia
- ☐ LS Lesotho .....
- ☐ LT Lithuania
- ☐ LU Luxembourg .....
- ☐ LV Latvia
- ☐ MD Republic of Moldova .....
- ☐ MG Madagascar .....
- ☐ MK The former Yugoslav Republic of Macedonia .....
- ☐ MN Mongolia
- ☐ MW Malawi .....
- ☐ MX Mexico .....
- ☐ NO Norway
- ☒ NZ New Zealand .....
- ☐ PL Poland .....
- ☐ PT Portugal .....
- ☐ RO Romania
- ☐ RU Russian Federation .....
- ☐ SD Sudan
- ☐ SE Sweden
- ☐ SG Singapore
- ☐ SI Slovenia .....
- ☐ SK Slovakia .....
- ☐ SL Sierra Leone
- ☐ TJ Tajikistan .....
- ☐ TM Turkmenistan .....
- ☐ TR Turkey .....
- ☐ TT Trinidad and Tobago .....
- ☐ UA Ukraine .....
- ☐ UG Uganda .....
- ☒ US United States of America .....
- ☐ UZ Uzbekistan .....
- ☐ VN Viet Nam .....
- ☐ YU Yugoslavia .....
- ☐ ZW Zimbabwe

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

- ☐ GM Gambia .....
- ☐ GW Guinea-Bissau .....
- ☐ ID Indonesia .....
- ☐ .....
- ☐ .....

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of _____

The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Sheet No. 4

Box No. VI PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country (in which, or for which, the application was filed)	Filing Date (day/month/year)	Application No.	Office of filing (only for regional or international application)
item (1) AUSTRALIA	24.02.97 24 FEBRUARY 1997	PO5268	
item (2)			
item (3)			

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

☒ The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s): 1

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA /

Earlier search *Fill in where a search (international, international-type or other) by the International Searching Authority has already been carried out or requested and the Authority is now requested to base the international search, to the extent possible, on the results of that earlier search. Identify such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request:*

Country (or regional Office):	Date (day/month/year):	Number:
AUSTRALIA	26 MAY 1997	97/558

Box No. VIII CHECK LIST

This international application contains the following number of sheets:

1. request	: 5	sheets
2. description	: 13	sheets
3. claims	: 3	sheets
4. abstract	: 1	sheets
5. drawings	: 2	sheets
Total	: 24	sheets

This international application is accompanied by the item(s) marked below:

1. ☐ separate signed power of attorney
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☐ priority document(s) *identified in Box No. VI as item(s):*
5. ☒ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing (diskette)
8. ☐ other *(specify)*:

Figure No. 1 of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

× [signature] G. L. DUNLOP
EXECUTIVE DIRECTOR
Authorised signatory of
CAST CENTRE PTY LTD

For receiving Office use only

1. Date of actual receipt of the purported international application:
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority specified by the applicant: ISA /
6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

Sheet No. ...5...

Supplemental Box *If the Supplemental Box is not used, this sheet need not be included in the request.*

Use this box in the following cases:

1. If, in any of the Boxes, the space is insufficient to furnish all the information: *in such case, write "Continuation of Box No. ..." [indicate the number of the Box] and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient;*

in particular:

(i) if more than two persons are involved as applicants and/or inventors and no "continuation sheet" is available: *in such case, write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below:*

(ii) if, in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked: *in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the applicant(s) involved and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is applicant:*

(iii) if, in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor/applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America: *in such case, write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III" (as the case may be), indicate the name of the inventor(s) and, next to (each) such name, the State(s) (and/or, where applicable, ARIPO, Eurasian, European or OAPI patent) for the purposes of which the named person is inventor:*

(iv) if, in addition to the agent(s) indicated in Box No. IV, there are further agents: *in such case, write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV:*

(v) if, in Box No. V, the name of any State (or OAPI) is accompanied by the indication "patent of addition," or "certificate of addition," or if, in Box No. V, the name of the United States of America is accompanied by an indication "Continuation" or "Continuation-in-part": *in such case, write "Continuation of Box No. V" and the name of each such State (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application:*

(vi) if there are more than three earlier applications whose priority is claimed: *in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI.*

2. If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning non-prejudicial disclosures or exceptions to lack of novelty: *in such case, write "Statement Concerning Non-Prejudicial Disclosures or Exceptions to Lack of Novelty" and furnish that statement below.*

Continuation of Box No. IX (Signatures)

× Joseph Barresi
JOSEPH GIOVANNI BARRESI

× M. Cooper
MALCOLM JAMES COUPER

× David St John
DAVID HENRY ST JOHN

× G Edwards
GEOFFREY ALAN EDWARDS

× Hao Wang
HAO WANG

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

5

Applicant's or agent's file reference GRM : FP 5793	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International application No. **PCT/AU 98/00115**	International filing date *(day/month/year)* 24 February 1999	Priority Date *(day/month/year)* 24 February 1997
International Patent Classification (IPC) or national classification and IPC **Int. Cl.**[6] C22C 21/02, 21/04		
Applicant (1) CAST CENTRE PTY LTD (2) BARRESI, Joseph Giovanni (et al)		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of **4** sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheet(s).

3. This report contains indications relating to the following items:

I	☒	Basis of the report
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☐	Lack of unity of invention
V	☒	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain documents cited
VII	☐	Certain defects in the international application
VIII	☒	Certain observations on the international application

Date of submission of the demand 18 September 1998	Date of completion of the report 12 January 1999
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. (02) 6285 3929	Authorized Officer **L.J. MENZ** Telephone No. (02) 6283 2347

I. Basis of the report

1. With regard to the **elements** of the international application:*

- [X] the international application as originally filed.
- [ ] the description, pages , as originally filed,
  pages , filed with the demand,
  pages , filed with the letter of .
- [ ] the claims, pages , as originally filed,
  pages , as amended (together with any statement) under Article 19,
  pages , filed with the demand,
  pages , filed with the letter of .
- [ ] the drawings, pages , as originally filed,
  pages , filed with the demand,
  pages , filed with the letter of .
- [ ] the sequence listing part of the description:
  pages , as originally filed
  pages , filed with the demand
  pages , filed with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

- [ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- [ ] the language of publication of the international application (under Rule 48.3(b)).
- [ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, was on the basis of the sequence listing:

- [ ] contained in the international application in written form.
- [ ] filed together with the international application in computer readable form.
- [ ] furnished subsequently to this Authority in written form.
- [ ] furnished subsequently to this Authority in computer readable form.
- [ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- [ ] The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. [ ] The amendments have resulted in the cancellation of:
   - [ ] the description, pages
   - [ ] the claims, Nos.
   - [ ] the drawings, sheets/fig

5. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement -

Novelty (N)	Claims	**1-14**	**YES**
	Claims		**NO**
Inventive step (IS)	Claims	**1-14**	**YES**
	Claims		**NO**
Industrial applicability (IA)	Claims	**1-14**	**YES**
	Claims		**NO**

2. Citations and explanations (Rule 70.7)

Citations

(a) AU 41041/78
(b) AU 35111/78
(c) AU 86630/75

Explanations

The citations do not disclose or suggest Al-Si-Mg alloys with a microstructure including a primary aluminium containing matrix and one or more iron-containing phases dispersed in the matrix and wherein the sole or predominant iron-containing phase is β phase that formed as a transition product of π phase.

Therefore claims 1 to 14 are novel and have inventive step.

The invention, as claimed, is industrially applicable.

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

The broad statements of invention and the corresponding claims 1 and 5 detail an alloy composition where Fe is present in an amount up to 0.05%. Therefore the alloy includes the possibility that no Fe is present. However, when referring to the phase structure of the alloy, the invention is characterised by iron-containing phases requiring the presence of some Fe in the alloy.